



NORWEGIAN CRUISE LINE®



April 26, 2005

Thomas K. Roth-Roffy  
Engineering Group Chairman  
National Transportation Safety Board  
Washington, D.C. 20594

Re: Boiler explosion aboard the S/S Norway, Miami, Florida, May 25, 2003

Dear Mr. Roth-Roffy:

In response to the Board's invitation to submit proposed findings of cause and safety recommendations with respect to the above referenced incident, we would like to take this opportunity to provide you with Norwegian Cruise Line's ("NCL's") findings, conclusions and proposed safety recommendations.

### Findings

1. The boiler explosion on board the *S/S Norway* was the result of the sudden release of steam and water at high pressure from the boiler system into the machinery spaces and adjacent accommodations. The immediate cause of that release of steam was the fracturing, separation and liberation of a large section of the sidewall header of the number 23 boiler measuring approximately 11 feet by 4 feet. The plating separated at the longitudinal weld seams. Subsequent close up inspection revealed that the weld seams had fractures.

2. As documented in section 10(f) of the NTSB's Factual Report<sup>1</sup> regarding "Metallurgical Testing of the Waterwall Header", several "coupons" were removed from different locations on the water wall header and the section liberated from it which were later subjected to metallurgical examination in the NTSB materials laboratory. The metallurgical testing found *evidence of fatigue cracks at the fracture surfaces*.

3. NCL held overall responsibility for the operation, maintenance and inspection of the *S/S Norway* and its equipment. As such, NCL had a computer based preventive maintenance program, AMOS-D, that was used to plan and document maintenance actions including the main boilers. As required by the original French Boiler Manuals, NCL also had the boilers cleaned and inspected at approximately 3000-hour intervals. (See section 5 of the NTSB's Factual Report).

---

<sup>1</sup> The Group Chairman's Factual Report, Engineering, S/S Norway Boiler Explosion Accident Number: DCA-03-MM-032.

4. NCL had the water in the boilers tested once per day by a second engineer specifically trained and assigned to that duty. NCL had a contract with The Drew Marine Division of Ashland Chemical to supply treatment chemicals and periodically conduct tests of the boiler water. NCL had this water testing routine in place to ensure that the proper residuals of treatment chemicals were maintained at all times and to detect the presence of contaminants in the water that may be injurious to the boiler. The primary goal of the chemical water treatment program was to minimize scale formation and to prevent corrosion of the boiler system. In addition, a service engineer from Drew Marine visited the vessel approximately once per month while the vessel was in port to review the record of tests done by the second engineer; to perform independent tests of the boiler water; and to provide training to members of the crew on boiler water testing procedures and proper chemical application. (See section 5 of the NTSB's Factual Report)

5. The boiler light off procedures used by the crew (and which were posted in the boiler room by the chief engineer) closely matched the recommendations of the boiler manufacturer as well as industry norms. (See section 6 of the NTSB's Factual Report)

6. The procedures for shutting down a boiler were also posted in the boiler room for use by the crew. The procedures for shutting down the boiler were also specified in the original boiler operation and maintenance manual. (See section 6 of the NTSB's Factual Report)

7. Harris Pye Marine Ltd. is one of the world's leaders in the field of marine engineering. Its main activity consists of the service of marine boilers. In 1997, Harris Pye was commissioned by NCL to investigate "the Possibility of Carrying Out Tube Renewals on Board SS "Norway" at Sea. Harris Pye stated in its "Marine Feasibility Study" that:

"At the time of the inspection, several observations were made by the engineering staff on tube failures currently being experienced in various parts of all boilers, but discussions with the Chief Engineer revealed **no current conditions of class on any drum nor header**. However, previous reports are believed to contain information of repairs carried out to surface cracks on some of these components, but, as these have been addressed to the satisfaction of attending surveyors, **we believe that these pressure parts are suitable for many more years of use.** (emphasis added)

Boiler expert Harris Pye concluded as follows:

"Although these boilers are around 40 years old and are currently suffering from ongoing tube failure, there is no report of the main components - i.e. headers or drums - having any Conditions of Class put on them...."

8. The survey, inspection and certification of a high pressure, high temperature, oil-fired boiler, may only be carried out by a delegated competent authority. NCL, including the

vessel's Flag State, Bahamas, delegated this responsibility to French classification society Bureau Veritas (BV). BV was founded in 1828 with the aim to provide insurers with all the information needed to assess the degree of trustworthiness and seaworthiness of ships and their equipment and to protect the safety of life and property. BV has been the Norway's classification society since the vessel was constructed.

9. Classification societies are organizations that establish and apply technical standards in relation to the design, construction and survey of marine-related facilities including ships and off shore structures. Those standards are issued by the classification society as published rules. The vessel that has been designed and built to the appropriate rules of a society may apply for a certificate of classification from that society. Following construction, inspection and testing of the vessel are carried out at regular prescribed intervals. The class rules specify the required interval and nature of inspection.

10. The flag state, Bahamas, also delegated the inspection of the Norway's boilers to BV. The Bahamas Maritime Authority (BMA) confirmed that it is a condition of registry in the Bahamas that the vessel remains "in class." This is intended to provide assurance of the satisfactory technical, structural conditions and proper maintenance of the vessel. (See section 8 of the NTSB's Factual Report)

11. The Bahamas (BMA) also carried out annual inspections to check the work carried out by BV on its behalf. The BMA confirmed that the Bahamas annual inspection report would not reference the boilers, unless the inspector noted something such as an overdue condition of class or obvious defect. No such references were seen regarding the *Norway*. (See section 8 of the NTSB's Factual Report)

12. NTSB interviews of the two BV surveyors recently assigned to the Norway prior to the boiler incident establish that neither one of them had a license for operating high pressure steam boilers. They also confirmed to NTSB that they did not receive any training from BV with regard to inspection of high pressure steam boilers.

13. BV's internal guidance (e.g., the "TNS") provides guidance regarding annual and periodic, external and internal, boiler inspection scope. Specifically, TNS-05 – Boilers Complete Surveys - section 2.2.1, defines a "complete survey" as follows: "A complete survey means *a full internal and external examination of all parts of the boiler and accessories* such as superheater, headers, economizer, air-heater internal organs and all mountings." (emphasis added) Regarding inspection of the lower drum, section 2.3.10 states that "an internal examination will not usually show much but any signs of pitting in the upper drum or tubes should be followed up by a further examination of the tubes via the lower drum." Section 2.8 on "Hydraulic tests" states that "this is required when:...b) the boiler has not been fully surveyed internally."

14. The rules for the design of boilers used for the S/S Norway (Chapter VIII, 1951 edition) were provided to the NTSB by BV. Article 111 on "Annual Surveys" in section 2 indicates that "The boilers and the steam receivers are to be examined *externally and internally*." Section 6 provides that "if the dimensions of the boiler or its openings will not allow the surveyor to enter them, or if certain important parts are inaccessible, a hydraulic test, as given in

Article 117 (Hydraulic test of boilers and superheaters) may be required. Article 112 on “Periodical Surveys” in section 2 also states that both “the boilers and steam receivers are to be examined *internally and externally*.”

15. BV’s TNS establishes that a complete survey has to include *internal and external* examination of the boiler. Further, if internal inspection is not possible, hydraulic tests should be carried out.

16. The interviews conducted by the NTSB established that the last BV surveyor assigned to the Norway before the accident did not go into the subject water wall header or any of the other pressure steam drums on the Norway during the surveys over the past years. He stated that BV did “not require” him to do so. The prior BV surveyor (from 1991 through 2001) also stated that he had not entered the water wall header of the drums and had only sighted the interior of the header from the outside. He, too, stated that BV guidelines did not require surveyors to enter into the water drum and the water wall header and that entry was only required into the steam drum. (See Section 7 of the NTSB Factual Report.)

17. The NTSB’s interviews also established that the BV surveyor who performed boiler surveys from the 1980s up to 1991 reported that he *did* enter the drums and headers during inspections. The Norway’s previous port engineer agreed that he had seen “BV people” inside the water headers. (See Section 7 of the NTSB Factual Report.)

18. NCL’s prior port engineer confirmed that you “have to” go into the water wall header because otherwise you cannot see what is inside. (See Section 7 of the NTSB Factual Report.)

19. Other classification societies’ inspection guidance also requires that surveyors internally inspect water drums (“mud drums”).

The American Bureau of Shipping (ABS), a U.S.-based classification society, has addressed the inspection of water drums or mud drums as follows<sup>2</sup>:

Water drums or mud drums shall be *opened and examined* for corrosion, pitting, type and extent of deposits and then washed clean. Normally these are left open until the last in case of anything such as nuts and bolts from the removal of the steam drum internal fittings, happens to fall into the tubes.

The U.S. Coast Guard provides in its guidance to inspectors of boilers in its Marine Safety Manual (MSM) that *the inside surface of the bottom drum* should be examined for evidence of pitting which is occasionally seen in boilers that have been out of service for long periods of time. In the section of the same chapter of the MSM dealing with pressure vessels, the

---

<sup>2</sup> The summaries of various classification societies’ guidelines referenced below were provided by these societies to the NTSB. They are not publicly available and cannot be released to the public without the approval of the individual classification societies. NCL’s reference to the guidelines is solely derived from section 10 of the NTSB Factual Report. NCL has italicized certain text which was not italicized in its original form for emphasis only.

MSM guides the inspectors to *carefully examine internal surfaces* for evidence of fractures or indications of deterioration. It states that the heat affected zone adjacent to all welds should be given special attention. All welded joints as well as nozzle connections and similar openings should be “thoroughly examined.” The MSM also emphasizes illumination and accessibility. If the inspector is not able to satisfactorily receive the area of concern with a bright light directed at the area being examined, a “satisfactory” internal examination cannot be conducted and the vessel should be tested by means acceptable to the OCMI to satisfy the periodic inspection requirement. Also, in accordance with MSM and Coast Guard Regulations, hydrostatic tests must be applied to all water tube boilers quadrennially (annually in the case of passenger vessels) regardless of whether internal exam is conducted. In the case of passenger vessels, the hydrostatic tests interval may be extended up to a period of not to exceed thirty (30) months since the last test provided that no less than two (2) hydrostatic tests are conducted within any five (5) year period.

Further, Det Norske Veritas (DNV) the Norwegian classification society, issued guidance to its surveyors on the conduct of boiler inspections as follows:

Due to the potential risks a boiler represents and the consequences any damage may have, it is of the utmost importance that the survey is performed in a “conscientious manner.” DNV also recognized that “too many auxiliary boiler designs are such that it is difficult to carry out visual internal examination. If proper internal examination is not possible, the surveyor may resort to ultrasonic and/or hydraulic testing to determine whether the boiler is in a safe working condition.” The DNV also recognized that “experience has shown that auxiliary boilers of 10-15 years of age are especially exposed to fatigue damage, thus testing as indicated above should be seriously considered by the surveyor if proper internal examination is not possible.” The scope of the survey of water and steam drums and internals is that “*an internal examination is to be made*, to look for cracks, corrosion, erosion, pitting and wastage of the shell, and vertical auxiliary boilers, especially attention to the circumferential and longitudinal welding seams. If internals or boiler shell is found wasted, thickness measurements are to be carried out as deemed necessary.” With respect to headers, DNV noted that “selected hand hold covers are to be removed for examination of internal surfaces and also for deposits, which may obstruct circulation particularly through water/membrane weld tubes. DNV stated that hydraulic testing should preferably not be carried out. If however, it was not possible to carry out a visual inspection due to for example lack of access (small auxiliary boilers), a test should be carried out with a test pressure not less than the max working pressure (a stamp on the marking plate) and not exceeding 1.25 times the working pressure.”<sup>3</sup>

DNV provided an inspection checklist for use by the surveyor. The section dealing with drums/header inspections stated:

---

<sup>3</sup> It is worth noting that DNV audited the vessel’s Safety Management System (“SMS”) to confirm that proper management of maintenance (ISM Code #10) policies and procedures were in place. In all, three (3) independent verifications were in progress without remarkable findings.

Water/steam drums and shells with internals.... If welds are not accessible to internal inspection, ultrasonic tests may be necessary to scan from the outside to detect any possible cracks developed due to corrosion on suspected areas.

The British classification society, Lloyd's Register of Shipping also issued boiler inspection guidelines to its surveyors in which it stated that:

"A surveyor must personally make a thorough examination of each boiler, together with its superheater, superheat control, air heater and economizer, if fitted."

The guidelines further state:

"Where the construction of a boiler *does not allow direct visual internal examination* of the shell, drums, or headers, the surveyor should be satisfied that the boiler is in a safe working condition by *resorting to remote viewing instruments, ultrasonic examination, or hydraulic testing* at 1.4 time the working pressure."

19. Bureau Veritas was aware of historical cracking of the boilers on board the S/S Norway. Fractures, referred to generally in the reports as "micro cracks," appear to have been first noted in May/June 1982. In 1982, BV Visa number 6 contained an excerpt with respect to boiler number 23: "cracks were found as follows: lower small header – whole length of outer longitudinal seam and about 1/3 of the length of the inner longitudinal seam, maxed up at 1 millimeter. All cracks were ground off."

20. In an August 20, 1996 internal memorandum, BV Miami advised BV London that ". . . particular attention has to be paid to the Main and Auxiliary Boilers. Some cracks were found since 1987 on the various drums of the MB as indicated hereafter. *Particular attention to be paid to monitor these details.*" Attached to the internal memorandum was a copy of the Lloyd Werft Bremerhaven report discussing cracks in boiler 21. Following this internal memorandum, in a September 5, 1996 memorandum to BV North America, BV London stated that it needed the "history of any problems with the boilers and major repair history *so that we are better guided for our surveys.*" This internal memorandum was either withdrawn or never reinstated in BV's active system to advise attending surveyors.

21. The NTSB October 23, 2003 draft engineering timeline findings contain a more complete summary of BV's awareness of historical cracking of the boilers. These documents record a continuous history of the finding of blisters and pitting, and main corrosions, cracks in the longitudinal and circumferential welds of the upper and lower drums.

22. The Vessel History Report based on survey records from Bureau Veritas provided via email from [michel.cazali@bureauveritas.com](mailto:michel.cazali@bureauveritas.com) to [sdahl@ncl.com](mailto:sdahl@ncl.com) dated May 17, 2000, refers to "permanent" maintenance, repair and renewal works on damaged main boilers. It also stated that "drum erosion and strong corrosion pitting have been a *permanent* source of damages."

23. In an NTSB interview, a senior representative of BV stated that when a “permanent” repair was completed, no monitoring of the repair was maintained by BV.

### **Proposed Findings of Cause**

In light of the findings as outlined above, Norwegian Cruise Line hereby submits the following as the probable causes of the explosion of boiler 23 on board the *S/S Norway* on May 25, 2003:

1. The water wall header in boiler 23 (also called a water wall drum) likely failed due to fatigue cracking in a longitudinal weld area of the drum/header.
2. A substantial contributory cause of the failure was classification society Bureau Veritas’ (BV) failure to comply with its own guidelines requiring internal and external examination of the drums of the boilers and, if not possible, hydraulic examinations of the water wall header/drum.

### **What NCL has Done After the Explosion**

On June 9, 2003, the Vice President of Technical Operations wrote an e-mail to all fleet wide chief engineers, vessel superintendents, and captains advising that with, immediate effect, he wanted all chief engineers to document whether the class societies’ attending surveyors entered the boiler drums and combustion chambers during every boiler survey. If they did not, this information was to be relayed back to their respective superintendents with a copy to the Vice President of Technical Operations.<sup>4</sup>

### **Recommendations**

**To: Bureau Veritas:**

It is recommended that Bureau Veritas in the future:

Comply fully with its own internal guidelines requiring its surveyors to internally and externally inspect boiler drums during its complete surveys. If it cannot do so, hydraulic examinations should be conducted;

---

<sup>4</sup> With the *Norway* no longer in active service, NCL has no other steam-boiler operated vessels in its fleet.

Review BV surveyors to ensure that they possess appropriate qualifications to conduct inspections; and

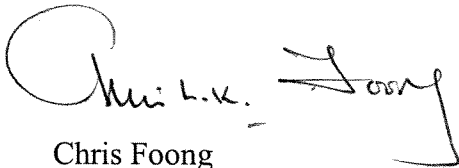
Ensure that internal memoranda noting conditions concerning state of equipment are published within their own system and also made known to ship owners/operators.

**To: All Classification Societies:**

That all classification societies adopt the guidelines issues by DNV in their quarterly newsletter Classification News (2/2004) regarding survey of aging steam boilers and which is cited in the NTSB's Factual Report. These guidelines instruct DNV's surveyors to perform a general internal examination of both the water and fire/gas side with a special focus on drums, headers and welding seams for possible cracks, corrosion, pitting and wastage. DNV instructed its surveyors that if the conditions described above were found, thickness measurements and/or other non-destructive testing methods should be performed.

**To: NCL and Other Cruise Lines:**

That it advise all of its Chief Engineers and Superintendents, as NCL has already done, to ensure and document that classification society surveyors have inspected *internally* all boiler drums and combustion chambers during every boiler survey. Chief Engineers should also be advised to relay back and document whether or not the surveyors conducted such an examination so that appropriate action to inspect can be undertaken either by the Owner or the Surveyor.

A handwritten signature in black ink, appearing to read "Chris L. K. Foong". The signature is stylized with a large initial "C" and a long horizontal stroke.

Chris Foong  
Vice President  
Technical Operations